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FERTILIZER RECOMMENDATIONS FOR WASHINGTON SOILS

[First Annual Report of the State Advisory Council on Soils and Soil Fertility]

For the purpose of furnishing the best information now available on soil fertilization to the farmers of Washington, and of developing a sound program of fertility maintenance and soil conservation, recommendations and suggestions have been formulated and approved for 1932 by the State Advisory Council on Soils and Soil Fertility.

These recommendations are based on the results of experimental work by the Experiment Stations of the State College of Washington; the experience of farmers and fertilizer companies; and tests, observations and demonstrations conducted by the County Agents and Smith-Hughes Agricultural teachers.

The organizations and personnel of the Advisory Council responsible for these recommendations are given in detail at the close of this bulletin.

Suggestions for Soil Fertilization

Economic returns from commercial fertilizers are most easily obtained from soils that are naturally fairly productive. Those soils that are naturally unproductive because of combinations of plant food deficiencies, inadequate moisture holding capacity, or poor physical make-up, cannot be expected to give profitable returns from applications of moderate quantities of fertilizers, and, therefore, the proposed suggestions are not applicable to soils in this class.

The use of commercial fertilizers for general field crops should not have to be continuous, but rather supplementary to other well planned soil management practices. In any good system of soil management, it should be possible to grow certain crops successfully with little or no commercial fertilizers, while other crops would require larger amounts. Crop rotations, including legumes for green manure, such for example as alfalfa, clover or vetch, and the use of commercial fertilizers for certain crops in the rotation, constitute good soil management practice. Under these conditions, satisfactory returns from commercial fertilizers are dependent largely upon the the kind and amount of plant food required, and the time and method of application.

The fertilizers, sulfate of ammonia, superphosphate, and muriate of potash mentioned in the recommendations, are used only as illustrations or as a basis for calculations of equivalent combinations, and no preference is intended for any specific form of fertilizer. Other soluble fertilizers may be

used successfully in equivalent amounts, as all soluble fertilizers are considered to be readily available in normal soils. However, there are insufficient experimental data in Washington at present to indicate that raw rock phosphate should be substituted for soluble phosphates in the fertilizer program. Some of the more common fertilizer materials with their plant food contents are listed in Table 1 for the convenience of the farmers. As listed, the amounts are equivalent to 100 pounds of sulfate of ammonia containing 20 per cent nitrogen (N), or 100 pounds of superphosphate containing 16 per cent phosphoric acid (P_2O_5), or 100 pounds of muriate of potash containing 50 per cent potash (K_2O), as the case may be, or to combinations of these.

Table 1. Common Soluble Fertilizer Materials.

Nitrogen Fertilizers

Name	Chemical Formula	Percentage of Nitrogen (N) Carried	Amount Equivalent to 100 lbs. Sulfate of Ammonia
Sulfate of Ammonia	$(NH_4)_2SO_4$	20	100
Nitrate of Soda	$NaNO_3$	16	125
Nitrate of Calcium	$Ca(NO_3)2$	15	133
Calcium Cyanamid	$Ca(Cn)2$	20	100
Calurea	$Ca(No_3)2 + (NH_2)_2CO$	34	59
Urea	$(NH_2)_2CO$	46	43
Leuna salpeter	$NH_4NO_3 + (NH_4)_2SO_4$	26	77

Tankage, dried blood, fish meal, are organic forms of variable composition and should be bought only on analysis.

Phosphorus Fertilizers.

Name	Chemical Formula	Percentage of Phosphate (P_2O_5) Carried	Amount Equivalent to 100 lbs. of Superphosphate
Superphosphate	$CaH_4(PO_4)2$	16	100
Treble Superphosphate	$CaH_4(PO_4)2 + H_3PO_4$	45	36
Bone Meal Acidulated	$Ca_2H_2(PO_4)2$	42	38

Combination Nitrogen and Phosphorus Fertilizers.

Name	Chemical Formula	Percentage Carried		Amount Equivalent to	
		Nitrogen (N)	Phosphate (P_2O_5)	100 lbs. Sulfate of Ammonia	100 lbs. Superphosphate
Ammo-phos **A**	$NH_4H_2PO_4$	11	48	182	33
Ammo-phos **B**	$(NH_4)_2HPO_4$	16	20	125	80

Potassium Fertilizers.

Name	Chemical Formula	Percentage of Potash (K_2O) Carried	Amount Equivalent to 100 lbs. muriate of Potash
Muriate of Potash	KCl	50	100
Sulfate of Potash	K_2SO_4	50	100
American-(Trona) Potash	KCl	60	83

Complete Synthetic Fertilizers.

Name	Percentage Carried			Amount Equivalent to 100 lbs.		
	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Sulfate of Ammonia	Superphosphate	Muriate of Potash
Nitrophoska	15	30	15	133	53.3	333
Ammo-phos-Ko	12	24	12	167	67	415.5

Equivalents for the amounts of plant food substances (nitrogen, phosphate and potash) represented in the sulfate of ammonia, superphosphate and muriate of potash used as a basis for fertilizer recommendations may be obtained by using proper combinations of suitable fertilizer materials and these combinations may be expressed as fertilizer formulas. For example, an application of a combination of 75 pounds of sulfate of ammonia, 300 pounds superphosphate, 75 pounds muriate of potash per acre is approximately equivalent to 500 pounds per acre of a 3-9-7 fertilizer. This same formula or combination may be obtained also by using 100 pounds of nitrate of soda, 107 pounds treble superphosphate, and 62 pounds American (Trona) potash; or by using 100 pounds of Amo-phos B, 175 pounds of superphosphate and 75 pounds of sulfate of potash. The formula for any of these combinations is 3-9-7, which means that they make up a fertilizer containing plant food in the proportion of 3 per cent nitrogen (N), 9 per cent phosphoric acid (P_2O_5), and 7 per cent potash (K_2O). In fertilizer formulas nitrogen is always stated first, phosphate second, and potash third.

SUGGESTIONS FOR WESTERN WASHINGTON

The following suggestions for pastures and general farm crops are based partly upon the results of a large number of field experiments and partly upon careful observations.

General Field Crops.

1. Make a suitable rotation of crops in which a legume such as clover, vetch or alfalfa is grown for hay or for green manure at least every third or fourth year, if possible.

2. To reduce the labor required in combating weed growth often resulting from manure, apply available manure as much as possible on non-legume hay meadows, such as the mixed grasses, at the rate of 6 to 8 tons per acre in fall, winter or early spring. This is ordinarily sufficient fertilization for such meadows.

Cereals.

Nitrogen seems to be the plant food element that is usually most deficient for cereals on many of the Western Washington mineral soils (soils other than muck and peat). Because of the relatively small cash returns from cereal crops, fertilizers should be applied sparingly.

1. Make a light top dressing of nitrogen fertilizer early in the spring at the rate of 100 to 200 pounds of sulfate of ammonia per acre or its equivalent in some other soluble nitrogen fertilizer.

2. When the soil is obviously deficient in available phosphorus, supplement the nitrogen with approximately 200 pounds of superphosphate or its equivalent in some other soluble phosphate fertilizer.

Alfalfa and Clovers.

Phosphorus and potash are the important plant food elements for alfalfa and clovers, because these crops can secure a large part of the nitrogen they require from the air, provided they are properly inoculated.

1. On soils not giving satisfactory yields of legumes, and seemingly deficient in available phosphorus and potash, use a fall application of approximately 350 pounds of superphosphate and 100 to 150 pounds of muriate of potash per acre, or the equivalent in some other soluble phosphate and potash fertilizers.

2. For new seedings on such soils, make a spring application of a complete fertilizer, equivalent to approximately 75 to 100 pounds sulfate of ammonia, 300 to 350 pounds superphosphate, and 75 to 150 pounds muriate of potash per acre.

3. In all cases where possible, prepare soils one or two years in advance of new seeding of legumes, applying such manures as are available and producing a cultivated crop as a means of controlling weeds.

Roots and Tubers.

Root crops, such as beets and mangels, and tubers, such as potatoes, respond best to complete fertilizers (nitrogen, phosphate and potash), and are well adapted to follow legume crops or meadows.

1. On soils that are not giving satisfactory yields, make a spring application of complete fertilizer equivalent to approximately 75 to 150 pounds sulfate of ammonia, 300 to 350 pounds of superphosphate, and 100 to 200 pounds muriate of potash per acre.

2. For beets or mangels, in addition to the foregoing complete fertilizer, apply a top dressing of approximately 200 pounds sulfate of ammonia per acre or its equivalent in some other nitrogen fertilizer.

Pastures.

Properly managed pastures that are well supplied with available plant food yield palatable, good quality feed, higher in mineral constituents than do grasses from unfertilized pastures.

1. For intensive fertilization, select only pastures that are naturally well supplied with moisture throughout the growing season or that can be irrigated economically during the dry season and that are composed initially of good pasture grasses.

2. Divide pasture in at least two fields (three or more are better if convenient). Graze alternately or successively as the case may be, changing fields often enough to avoid over-grazing of the pastured field and to prevent over-growth of the grass in the unpastured field or fields. When stock is moved from a pastured field, cut ungrazed patches of grass and spread droppings.

Manure System of Pasture Fertilization.

1. When manure is not needed in the other fields, apply to pasture in fall or winter at the rate of 6 to 8 tons per acre.

2. Supplement manure with a fall or winter application of approximately 300 pounds of superphosphate per acre or its equivalent in some other soluble phosphate fertilizer.

3. Top dress the pasture fields systematically with nitrogen fertilizers during the growing season, because nitrogen is required in large amounts to build protein in the young grass.

4. Early in the spring use 100 pounds sulfate of ammonia per acre or its equivalent in some other soluble nitrogen fertilizer. It is very desirable to rotate grazing of pasture. When this rotation is practiced, use a second 100 pounds per acre in April, and a third late in May or in the first part of June.

5. In any case where rotation of grazing is impossible, apply late in May 20 pounds of sulfate of ammonia per acre, omitting the additional applications recommended in the preceding paragraph. This method, however, is much less desirable than the recommendations where rotation is practised.

Commercial Fertilizer System for Pastures.

When manure is not available, substitute commercial fertilizers as follows:

1. For pastures that are naturally producing fairly good yields, make a fall or winter application of approximately 300 pounds superphosphate per acre or its equivalent in some other form of soluble phosphate.

2. For less well producing pastures make a fall or winter application of a complete fertilizer equivalent to approximately 50 to 75 pounds sulfate of ammonia, 300 pounds superphosphate, and 50 to 75 pounds muriate of potash per acre.

3. Make the same spring top dressings with nitrogen fertilizers during the growing season as recommended for the manure systems.

IRRIGATED DISTRICTS IN EASTERN WASHINGTON

The soil management in general farming should be so conducted that a large part of the nitrogen required by the crops is obtained by growing legumes, such as alfalfa or clover, in the crop rotation system.

Cereals.

1. When cereals are grown following a legume, no nitrogen fertilizer should be needed.

2. If the soil is very deficient in available phosphorus, use a soluble phosphate equivalent to approximately 200 pounds of superphosphate per acre.

3. If cereals are grown following non-legume crops, make a light top dressing early in the spring of a soluble nitrogen fertilizer equivalent to 100 to 200 pounds of sulfate of ammonia per acre.

Alfalfa and Other Legumes.

In the Ellensburg district, available phosphorus seems to be deficient in many of the soils. Not sufficient data have been obtained in the other irrigated districts to suggest fertilizer practices for those districts.

1. For soils that are deficient in available phosphorus, make a fall or winter application of approximately 300 pounds superphosphate per acre or its equivalent in some other soluble phosphate fertilizer.

2. On some of the lower Yakima valley soils, experiments at the Irrigation Branch Station at Prosser indicate that nitrogen is the main limiting factor. Applications of phosphate may be helpful on some of the older soils of this area. Adequate experimental data are not available to make definite recommendations possible this year.

Roots and Tubers.

Roots such as beets and mangels, and tubers such as potatoes should preferably follow a legume crop. Phosphate and potash are the most important nutrients that may have to be added in the Ellensburg district.

1. On soils that appear to be deficient in available phosphate and potash, use a phosphate-potash combination in the spring, equivalent to approximately 300 to 450 pounds superphosphate, and 125 to 200 pounds of muriate of potash per acre. Make an additional top dressing of approximately 200 pounds sulfate of ammonia per acre or its equivalent in some other nitrogen fertilizer for root crops other than potatoes.

2. There are evidences that in the lower Yakima valley applications of 300 to 500 pounds of superphosphate on soils obviously deficient in available phosphate are beneficial, but experimental data are not sufficient to justify definite recommendations.

Pastures.

Pastures should be divided into two or more fields and grazing rotated, changing fields often enough to prevent over-grazing of one field and overgrowth in others. Properly managed and well fertilized pastures yield feed of superior quality.

1. Grass pastures should receive manure, when available, at from 6 to 8 tons per acre, applied in fall or winter.

2. Supplement manure with a fall or winter application of approximately 300 pounds of superphosphate per acre, or its equivalent in some other soluble phosphate.

3. Top-dress the pasture systematically with nitrogen fertilizers during the growing season to build protein in the young grass.

4. Early in the spring, use 100 pounds of sulfate of ammonia per acre or its equivalent in some other form of nitrogen fertilizer. If the rotation system of grazing is practised, apply a second 100 pounds in mid-spring, and a third late in May or early June.

5. If rotation of grazing is impossible, apply the equivalent of 200 pounds of sulfate of ammonia per acre in May or June, omitting the additional applications recommended in the preceding paragraph. This method,

however, is less desirable than the recommendations where rotation is practised.

Commercial Fertilizer System for Pastures.

When manure is not available, substitute commercial fertilizers as follows:

1. For pastures that are naturally producing fairly good yields, make a fall or winter application of approximately 300 pounds of superphosphate per acre or its equivalent in some other soluble phosphate.

2. For less well-producing pastures, make a fall or winter application of a complete fertilizer (nitrogen,phosphate and potash) equivalent to approximately 50 to 75 pounds sulfate of ammonia, 300 pounds superphosphate and 50 to 75 pounds muriate of potash, per acre.

3. Top dress systematically with nitrogen fertilizers during the growing season.

4. In the case of legume pastures on soil known to be deficient in available phosphate, make a fall or winter application of approximately 300 pounds of superphosphate per acre, or its equivalent in some other soluble phosphate.

Dry Land Cereals of Eastern Washington.

Although much work has been done on wheat soil fertilization, from an economic viewpoint it seems undesirable to make specific recommendations at this time. The use of legume crops on hilltops for pasture, hay, or manure crops, is desirable where rainfall is sufficient and it is otherwise practicable. Light applications of a nitrogen fertilizer on hilltops may in some cases be justified.

FERTILIZER PROGRAM FOR APPLE ORCHARDS

The apple orchard fertilizer program is based upon responses observed from 3 to 5 years upon experimental plots in north central Washington. These observations, while not final, are of interest to fruit growers and were the bases upon which the recommendations were tentatively formulated.

1. Firmness of Flesh as Measured by Pressure Tester: (a) With fruits of the same size and color any one season, there have been no significant differences in firmness of texture of Jonathan apples at harvest time or after three months' storage at 32° F., as a result of the fertilizer treatments.

(b) At harvest, there has been little difference in the firmness of fruit from season to season between comparable sizes and color. After three months' storage at 32° F., however, all lots varied from season to season. Hence, with uniform samples of comparable size, color and maturity, other environmental conditions exerted greater influence upon firmness of flesh than did the fertilizer treatment.

(c) The fertilizer application, however, may affect the size, degree and per cent of red color and the time of maturity. Hence, to this extent the firmness of the fruit of representative samples from the different fertilizer plots may be affected in conformity with these preceding factors.

2. Jonathan Breakdown: Large size fruit is more subject to Jonathan breakdown than is smaller size fruit. Furthermore, fruit on trees having a large leaf area per fruit is more susceptible than is fruit on trees having a limited leaf area per fruit. Thus, insofar as fertilizer applications may increase the size of fruit, and may give a relatively large leaf area per fruit borne, the susceptibility to Jonathan breakdown may be increased.

3. Soft Scald: Observations to date indicate that factors other than the fertilizer applications are primarily responsible for soft scald.

4. Fruit Bud Injury: Evidence indicates that there has been no measurable direct influence upon winter injury to buds from the application of fertilizers except as better vigor of the tree may enable it to withstand adverse conditions somewhat more satisfactorily than will weak trees.

5. June Drop: With the exception of two plots, the variation in the amount of June drop between the trees within a plot has been as great as between plots. Unfavorable environmental factors, including inadequate soil moisture, winter injury, cultural practices and insect attacks, exert a greater combined influence than do fertilizers upon the June drop, except where trees may be weak because of inadquate mineral plant foods. When, however, either phosphate or potash is used alone, the June drop has been consistently greater, even with a lesser fruit set, than that on unfertilized plots.

6. Set of Fruit: Nitrogen alone or in combination has favored an increased set of fruit in comparison with unfertilized plots and plots to which potash or phosphate alone have been applied. Where nitrogen is not a limiting factor, the application of phosphate and potash together without further nitrogen has equaled the set of combinations including nitrogen. The combination of nitrogen and phosphate has given as large a set as any other fertilizer application.

7. Thinning: While growers are interested primarily in the harvested crop, this alone should not be taken as a measure of yield response to fertilizers. By thinning, the crop on each tree may be made nearly uniform. With trees having a heavy set, more fruit is thinned than with trees having a light set, so the ultimate crop matured may be nearly alike in amount. For example, thinnings from the trees in the plots receiving nitrogen alone or in combination have been much greater than the thinnings from trees in plots not receiving nitrogen, but the actual crop harvested has not shown marked difference.

8. Yield of Fruit per Tree: Total yield is profoundly influenced by climate, cultural practices, and soil types. Nevertheless, where nitrogen has been a limiting factor the addition of nitrogen either alone or in combination with phosphate or potash fertilizers has resulted in increased yields. The other element, which with certain soils has benefited yield, is phosphorus when applied in combination with nitrogen.

9. Size of Fruit: Size of fruit is influenced by tree load, leaf area available, and moisture relationships, in addition to the effect of the fertilizers. It does not, therefore, necessarily follow that fertilizers may result in size

increase of fruit if at the same time tree load is increased. Observations, however, indicate that nitrogen alone or in combination tends to maintain size of fruit notwithstanding an increased tree load as compared with the unfertilized plot. As compared with fertilization with either phosphate or potash alone, however, nitrogen either alone or in combination tends to increase the average size of individual fruits.

10. Color of Fruit: Nitrogen either alone or in combination tends to oppose maximum color development, primarily by: first, delaying maturity attainment of the crop, and second, by giving more shade from increased leaf development. Certain other factors that may influence color development are as follows: unfavorable growing conditions, excessively high summer temperatures, reduced sunlight through haze or cloudy weather, crowded condition of trees, insufficient pruning, excessively vigorous vegetative growth, attacks of leaf-injuring insects, and insufficient maturity before harvest. Under some conditions, larger size of fruit and increased total tree yield may offset possible lowered returns from lessened color development.

11. Factors Related to Tree Growth: such as tree circumference, terminal growth (diameter and length), size and color of individual leaves, may be benefited by the application of nitrogen where this element is a limiting factor.

12. Recommendations: In the fertilizer program, nitrogen is likely to be the first limiting factor with fruit trees on irrigated soils of Washington east of the Cascades. Under average ordinary conditions, sufficient nitrogen may be supplied by several means.

(a) Barnyard manure, if available, can be employed at the rate of 5 to 8 tons or its equivalent in leguminous hay (1 to 2 tons) per acre. They should, preferably be applied from late fall to early spring.

(b) Leguminous cover crops may be grown in the orchard when available water supply and light conditions permit a good stand to be maintained. The active organic matter introduced by either manure or cover crop is beneficial.

(c) Unless heavy cover crop growth can be maintained, the addition of about 2½ pounds per tree of sulfate of ammonia or the equivalent of other soluble nitrogen fertilizer may be justified. On trees lacking in vigor, this may be increased to 5 pounds. A suitable time to apply this nitrogen is during the dormant season, preferably on a snowfall if feasible.

(d) Experimental data are as yet inadequate to justify specific recommendations as to phosphate and potash. It is possible that in some orchards, phosphorus may be of indirect benefit to the trees through the influence of the growth of a leguminous cover crop. Where the grower is convinced it is profitable under his orchard conditions to apply these elements in addition to 2½ pounds per tree of sulfate of ammonia or other equivalent soluble nitrogenous fertilizer, general experience indicates they should be applied in amounts not exceeding 6

to 10 pounds of superphosphate and 4 to 6 pounds of muriate of potash or the equivalent of other soluble phosphate and potash fertilizers, per mature tree.

SMALL FRUIT AND TRUCK CROPS*

Because of inadequate data in regard to specific responses of small fruit and truck crops as to definite amounts of manures and of various commercial fertilizers applied alone or in combinations on Washington soils, specific recommendations for the fertilization of these crops are not justified at this time. However, on the basis of general practices and careful field observations, the following suggestions appear to be reasonable.

Although barnyard manure and other animal manures give good results on all soils, they can be used most advantageously on mineral soils(soils other than muck and peat). Therefore, when only limited quantities of manure are available, they should be used preferably on mineral soils or in reduced amounts if used on muck and peat soils.

The suggested rates of commercial fertilizer applications are based on sulfate of ammonia containing 20 per cent nitrogen (N), superphosphate containing 16 per cent phosphorus pentoxide (P_2O_5) and muriate of potash containing 50 per cent of potash (K_2O).

SUGGESTIONS FOR WESTERN WASHINGTON

Raspberries and Blackberries.

Raspberries and blackberries are perennial crops requiring fertile soil and special care in order to make profitable returns. Therefore, these crops should be planted only on well drained soils that are in good physical condition.

1. On mineral soils (soils other than muck and peat), make a fall or winter application of 400 to 600 pounds of superphosphate per acre, or its equivalent in some other soluble phosphate fertilizer in addition to 8 to 12 tons of barnyard manure, or 5 to 6 tons fresh sheep manure, or 3 to 5 tons fresh poultry manure per acre.

2. On muck or peat soils make the same application of superphosphate but reduce the application of manure to one-half the amounts suggested in the preceding paragraph and add the equivalent of 75 to 100 pounds of muriate of potash per acre.

3. When manure is not available for either mineral, muck, or peat soils, make a late winter or early spring application of 125 to 175 pounds of sulfate of ammonia, 500 to 700 pounds of superphosphate, and 100 to 150

*There being inadequate time at the meeting February 15, 1932 for the Advisory council to prepare for formal adoption in detail, recommendations covering berries and truck crops in western Washington and the Yakima, Columbia, and Walla Walla valleys, the Council considered and approved basic information and data available on these crops for these areas and authorized County Agent E. C. Durdle of Benton County, in consultation with Superintendent H. P. Singleton of the Prosser Branch Experiment Station and County Agent H. C. Burgess of Walla Walla County, to prepare the detailed recommendations to be made part of this report.

pounds of muriate of potash per acre, or the equivalent in other soluble nitrogen, phosphate and potash fertilizers. This fertilization is equivalent to 750 to 1050 pounds per acre of a complete fertilizer of an approximate 3-10-7 composition. If plants are weak or canes are short, the nitrogen may be increased to 250 to 350 pounds sulfate of ammonia per acre.

Strawberries.

For new plantings of strawberries the soil should be prepared one or two years in advance of planting by applying such manures as are available.

1. When manures are available following harvest of the crop they may be applied at the rate of 6 to 8 tons of barnyard manure or 3 to 4 tons of fresh sheep manure, or 2 to 3 tons of fresh poultry manure, in addition to 400 to 600 pounds of superphosphate per acre or its equivalent in some soluble phosphate fertilizer.

2. When manures are not available apply after harvest of the crop, 75 to 150 pounds of sulfate of ammonia, 300 to 500 pounds of superphosphate, and 75 to 150 pounds of muriate of potash per acre, or the equivalent in some other soluble nitrogen, phosphate and potash fertilizers. This fertilization is equivalent to 500 to 1000 pounds per acre of a complete fertilizer of an approximate 3-10-7 composition.

3. If plants lack vigor, apply early in spring from 100 to 200 pounds sulfate of ammonia per acre to aid fruit set.

Leafy Vegetables

(Including Cabbage, Asparagus, Celery and Rhubarb.)

1. When manures are available apply on mineral soils in fall or before planting time, 12 to 15 tons of barnyard manure, or 6 to 8 tons of fresh sheep manure, or 4 to 6 tons of fresh poultry manure in addtion to 600 to 800 pounds of superphosphate per acre or its equivalent in some other soluble phosphate fertilizer.

2. On muck or peat soils make the same application of superphosphate, but reduce the application of manure to one-half the amounts suggested in the preceding paragraph and add the equivalent of 75 to 100 pounds of muriate of potash per acre.

3. If growth is not satisfactory, side-dress with 100 to 200 pounds of sulfate of ammonia per acre or its equivalent in some other soluble nitrogen fertilizer, preferably before the plants are one-third grown.

4. When manures are not available, use on both mineral and muck or peat soils an early spring application of 300 to 350 pounds of sulfate of ammonia, 600 to 750 pounds of superphosphate, and 75 to 100 pounds of muriate of potash per acre, or the equivalent in some other soluble nitrogen, phosphate and potash fertilizers. This fertilization is equivalent to 1000 to 1200 pounds per acre of a complete fertilizer of an approximate 6-10-4 composition.

Lettuce; Root and Seed Crops.

(Including Beets, Carrots, Peas, Beans, and Sweet Corn)

1. The manure applications are the same as for leafy vegetables.

2. When manures are not available use on both mineral and muck or peat soils an early spring application of 200 to 250 pounds sulfate of ammonia, 500 to 600 pounds superphosphate and 150 to 200 pounds of muriate of potash per acre or the equivalent in some other nitrogen, phosphate or potash fertilizers. This fertilization is equivalent to 1000 to 1200 pounds per acre of a complete fertilizer of an approximate 4-8-8 composition.

3. If growth is not satisfactory, side-dress with 150 to 200 pounds of sulfate of ammonia per acre or its equivalent in some other soluble nitrogen fertilizer, preferably before the plants are one-third grown.

Bulbs and Bulb-like Plants.

1. When manures are available, apply on mineral soils 10 to 12 tons of well-rotted barnyard manure per acre, or half those amounts if sheep or poultry manures are used. In addition to the manure, use 500 to 700 pounds superphosphate per acre or the equivalent in some other soluble phosphate fertilizer.

2. On muck or peat soils, use the same amount of superphosphate, but reduce the application of manure to one-half the amounts suggested in the preceding paragraph, and add 75 to 100 pounds muriate of potash.

3. When manures are not available, use from 150 to 250 pounds of sulfate of ammonia, 700 to 900 pounds of superphosphate and 200 to 300 pounds of muriate of potash per acre, or the equivalent in some other soluble nitrogen, phosphate and potash fertilizers. This fertilization is equivalent to 1000 to 1500 pounds per acre of a complete fertilizer of an approximate 3-10-10 composition.

YAKIMA, COLUMBIA, AND WALLA WALLA VALLEYS FERTILIZATION

The suggestions for fertilization of soils in these valleys are based partly on the limited amount of experimental data available and partly on careful field observations.

Asparagus.

1. Apply in winter or early spring 10 to 12 tons of barnyard manure or 6 to 8 tons of sheep manure in addition to 200 to 400 pounds of superphosphate and 100 to 150 pounds of sulfate of ammonia per acre or the equivalent in some other soluble nitrogen and phosphate fertilizers. After the cutting season add from 150 to 300 pounds of sulfate of ammonia per acre or its equivalent in some other soluble nitrogen fertilizer.

2. When manure is not available, cut tops in the fall and disk in or run them through ensilage cutter and spread them over the field. At this time broadcast 200 to 300 pounds of sulfate of ammonia and 300 to 400 pounds

of superphosphate per acre or the equivalent in some other soluble nitrogen and phosphate fertilizers. Make two applications of 100 to 150 pounds each of sulfate of ammonia per acre during the cutting season.

Lettuce.

Lettuce may well follow early potatoes.

1. If manure has not been applied for potatoes, use 10 to 12 tons of barnyard manure or 6 to 8 tons of sheep manure per acre, and on the older soils, supplement the manure with 300 to 500 pounds of superphosphate. If growth is not satisfactory, side-dress with 100 to 200 pounds of sulfate of ammonia per acre preferably before the plants are one-third grown.

2. If manure has been applied for early potatoes, use 200 to 400 pounds of sulfate of ammonia per acre at planting time. If growth is not satisfactory, side-dress with 100 to 200 pounds of sulfate of ammonia per acre, preferably before the plants are one-third grown. Sulfate of ammonia and superphosphate may be replaced by other soluble nitrogen and phosphate fertilizers.

Strawberries.

1. A good supply of organic matter is desirable for soils to be planted to strawberries. This may be accomplished by the application of 10 to 12 tons of manure per acre, by plowing under of a good leguminous cover crop, or by plowing up an established alfalfa or sweet clover field. On the older soils apply in addition to the organic matter the equivalent of 500 pounds superphosphate and 200 pounds of muriate of potash at the time the field is plowed previous to planting.

2. The second and succeeding years, apply at the time one-half of the row is turned under, following harvest, from 250 to 500 pounds of sulfate of ammonia, 300 pounds of superphosphate, and 200 pounds of muriate of potash per acre or the equivalent in some other nitrogen, phosphate and potash fertilizer.

Onions.

1. When the field has not been in alfalfa or sweet clover for several years, apply 12 tons of manure per acre and on the older soils make an application of 400 pounds of superphosphate per acre in addition to the manure.

2. On soils where alfalfa or sweet clover has just been plowed under, apply 300 to 500 pounds of superphosphate per acre. During the second year following alfalfa, use 200 to 400 pounds of sulfate of ammonia and 400 pounds of superphosphate per acre. During the third year following alfalfa or sweet clover, use 500 to 600 pounds of sulfate of ammonia and 500 pounds of superphosphate per acre or the equivalent in some other soluble nitrogen and phosphate fertilizers.

Spinach.

1. Application of 10 to 12 tons of manure with 300 to 400 pounds of superphosphate per acre should give sufficient fertility.

2. If manure is not available, apply 300 to 500 pounds of sulfate of ammonia and 350 to 500 pounds of superphosphate per acre or the equivalent in some other soluble nitrogen and phosphate fertilizers.

Tomatoes.

1. On soils where alfalfa or sweet clover has just been plowed under, apply the equivalent of approximately 500 pounds of superphosphate and 250 pounds of muriate of potash per acre. No manure or nitrogen fertilizer should be required.

2. On older soils that have not been in alfalfa recently, or where fertility and organic matter have not been maintained, use from 5 to 6 tons of manure and 500 pounds of superphosphate per acre or a combination of 200 to 300 pounds of sulfate of ammonia, 500 pounds of superphosphate and 250 pounds of muriate of potash per acre or the equivalent in some other combination of soluble nitrogen, phosphate and potash fertilizers.

Melons.

1. Manure is very desirable in the production of melons, particularly cantaloupes. Use 10 to 12 tons of manure per acre and on the older soils supplement this with 400 pounds of superphosphate per acre.

2. Where commercial fertilizers alone are depended upon, use a combination of 200 to 400 pounds sulfate of ammonia, 500 to 600 pounds of superphosphate, and 200 to 300 pounds of muriate of potash or the equivalent in some other combination of soluble nitrogen, phosphate and potash fertilizers.

LIME IN SOIL MANAGEMENT PROGRAM.

The place of lime in the general soil management program is a subject worthy of study and observation. A considerable amount of experimental work is under way and in contemplation but data so far are inadequate to warrant the making of specific recommendations.

WILL EXPAND RECOMMENDATIONS NEXT YEAR.

The Advisory Council on Soils and Fertility, meeting February 15, 1932, adopted the foregoing recommendations and suggestions as the best that can be made for the ensuing crop year. They are based upon the best experimental data of the experiment stations of the State College of Washington, the test plots supervised throughout the state by county agricultural agents and Smith-Hughes high school agricultural instructors, in cooperation with the Soils Section of the State College, and widespread observation of the practices of successful growers.

The Council recommends:

1. That farmers who are in doubt as to the fertility requirements of their soils consult with their county agent, or Smith-Hughes agricultural instructor, or write to the Soils Section of the Department of Agronomy at the State College of Washington, Pullman.

2. That whenever practicable, individual farmers establish test plots on their own farms, with the assistance of county agents, agricultural instructors or experiment station men, when possible, and keep accurate records of results with different fertilizers on their respective crops.

Upon the basis of new and old data available, following the 1932 crop year, the Council expects to issue a revision of the foregoing recommendations for the crop year of 1933.

ORGANIZATION AND PERSONNEL, STATE ADVISORY COUNCIL ON SOILS AND SOIL FERTILITY

Upon the call of the Washington State Chamber of Commerce, a meeting of representatives of the State College of Washington, the State Department of Agriculture, State Department of Vocational Agricultural Education, farm organizations, fertilizer companies, State Bankers Association, agricultural divisions of the railroads, and the agricultural press, was held in Seattle, December 18, 1931, for the purpose of considering ways and means of developing a long-time program in soil conservation and soil fertility for the state of Washington. Among actions taken, was authorization of the appointment of an Advisory Council on Soils and Soil Fertility.

The members of this Council, as subsequently appointed by H. J. Gille, chairman of the land utilization committee of the State Chamber of Commerce, are as follows:

F. E. Balmer, Director, Agricultural Extension Service, State College of Washington, Pullman.
J. W. Bradley, Washington State Bankers Association, Spokane.
George J. Cannon, Agricultural Development Agent, Great Northern Railway, Spokane.
A. R. Chase, County Agent of Chelan County, Wenatchee.
Fred W. Clemens, of the Washington Farmer, Spokane.
E. C. Durdle, County Agent of Benton County, Kennewick.
D. W. Dwinnell, Washington Farm Bureau Federation, Outlook.
H. J. Gille, Chairman, Land Utilization Committee, State Chamber of Commerce, and Director, Agricultural and Industrial Development, Puget Sound Power and Light Company, Seattle.
J. A. Guitteau, Director, Vocational Agriculture, Department of Public Instruction, Olympia.
A. S. Goss, Master, Washington State Grange, Seattle.
Elon Gilbert, fruit interests, Yakima.
Henry R. Hobson, Washington Agricultural Council, Wenatchee.
E. C. Johnson, Dean, College of Agriculture, and Director, Agricultural Experiment Station, State College of Washington, Pullman.
Dr. J. W. Kalkus, Superintendent, Western Washington Experiment Station, Puyallup.
Senator W. J. Knutzen, dairy interests, Burlington.
Frank Leckenby, of the Charles H. Lilly Company, Seattle.
Clayton L. Long, American Cyanamid Company, Corvallis, Oregon.
M. E. McCollam, the New York Potash Export Corporation, San Jose, California.
C. C. McCormick, Agricultural Development Agent, Chicago, Milwaukee, St. Paul & Pacific Railway, Spokane.
F. A. Norton, Washington State Horticultural Association, Grandview.
Hon. A. E. Olson, wheat interests, Pullman.
C. W. Orton, Puget Sound Bulb Exchange, Sumner.
Dr. E. L. Overholser, Head, Department of Horticulture, College of Agriculture, and Agricultural Experiment Station, State College of Washington, Pullman.
F. L. Overley, Associate Horticulturist, Agricultural Experiment Station, State College of Washington, Wenatchee.
A. M. Richardson, County Agent of Pierce County, Tacoma.
G. V. Robinson, Feed and Fertilizer Inspector, State Department of Agriculture, Seattle.
W. P. Stapleton (Chairman), Agricultural Development Agent, Northern Pacific Railway, Seattle.

George B. Stuart, President, Western Washington Horticultural Association, Monroe.
M. C. Taylor, Magnolia Fertilizer Company, Seattle.
Dr. S. C. Vandecaveye, Head, Soils Section, Department of Agronomy, College of Agriculture and Agricultural Experiment Station, State College of Washington, Pullman.

Upon the call of Mr. H. J. Gille, the Council met again in Seattle February 15, 1932 and, upon the basis of fertilizer work done and data compiled by the Agricultural Experiment Station, State College of Washington, the Western Washington Experiment Station, the State College Extension Service, and the Smith-Hughes Vocational Agricultural Instructors, and recognized practices of successful farmers under the different conditions of soil and climate throughout the state, prepared the foregoing suggestions and recommendations given as the best available for farmers for the crop year of 1932. It is the intent of the Council to meet annually, adding to or modifying each previous year's recommendations on the basis of new experimental data, and to take such other action as seems advisable for the development of the general soils conservation program.

Pursuant to the action of the Advisory Council on Soils and Soil Fertility this material is being published by the Agricultural Extension Service of the State College of Washington.

Published and distributed in furtherance of the act of May 8, 1914, by the State College of Washington, Extension Service, F. E. Balmer, Director, and U. S. Department of Agriculture cooperating.